Remote Sensing for Acid Mine Drainage

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Abstract

Mine drainage is the most significant source of water pollution in the coal fields of the Appalachian region of the United States. Large volumes of acid mine drainage (AMD) flow out of the ground (by both gravity and artesian flow) in areas adjacent to, and within several of the region's rivers, including the Monongahela and the Youghiogheny Rivers. In the case of the former, there is significant potential for future problems as commercial mines that were closed about a decade ago are filling up with water and will likely discharge into the Monongahela River. In the case of the Youghiogheny River, mine drainage from early- to mid-century underground mines workings (pools) have been generating an adverse impact on the river's water quality for decades. The Youghiogheny River's ability to maintain aquatic life, and it's recreational and regional development potential remains threatened as the result of these early mining activities. Furthermore, several major tributaries also discharge polluted (metal-laden) water into the Youghiogheny River. DOE/FETC had teamed-up with the U.S. Geological Survey, the PaDEP and several regional watershed organizations to conduct a synoptic water quality survey of the Youghiogheny River to determine which source, tributaries or artesian groundwater flow in the river channel, is the most significant threat to the health of the river. Although the synoptic water quality survey quantified the sources of pollution, it could not specifically identify where artesian flow was entering through the river bottom due to accuracy limitations in existing river gaging technology.

A remote sensing technique, thermal infrared (IR) imagery, was successfully applied this past winter by the Federal Energy Technology Center (FETC) of the Department of Energy (DOE) for the diagnosis of water pollution problems on a watershed basis. This first-time application of the airborne thermal IR technology to mine drainage issues identified locations where the ground water contacts the cooler surface (land and water) within the following survey sites: (1) a 90-mile segment of the Youghiogheny River's lower basin, (2) a 167 square mile watershed (Sewickley Creek), (3) a 100-mile segment of the Monongahela River (from McKeesport, PA to the West Virginia state line); and (4) a five-mile segment of three streams in West Virginia (West Fork River, Buffalo Creek and Dunkard Creek), starting at their confluences with the Monongahela River. The objectives of applying remote sensing technologies to suspected or known environmental problem areas include: (1) quickly and efficiently identifying pollution sources on a regional and/or watershed basis, (2) accurately targeting subsequent ground-truthing activities and site-specific evaluations, (3) identifying specific hydrologic problems or pollution characteristics so that appropriate remediation strategies can be designed and/or implemented, and (4) providing a technical and scientific foundation for the development of regional watershed remediation plans.

The Remote Sensing Laboratory (RSL) operated by Bechtel Nevada (BN) for the Department of Energy in Las Vegas, Nevada conducted the thermal IR surveys with a Daedalus AADS1286 Multispecral Scanner System (MSS) configured with dual thermal infrared detectors as the primary sensor. This configuration allowed the 12 channel, "state-of-the-art" airborne electro-optical line scanner to use both 3-5 and 8-12 micron detectors to sense emitted thermal infrared energy. This sensor package was mounted on a MBB BO-105 helicopter and flown at an altitude of 1,300 feet and could detect temperature differences as low as a 0.1° centigrade. The ground sample distance (GSD) for this study was approximately one square yard or three square feet and the surveys were conducted at night to eliminate thermal loading from the sun. A total of 10 days of flight time were required to complete all surveys.

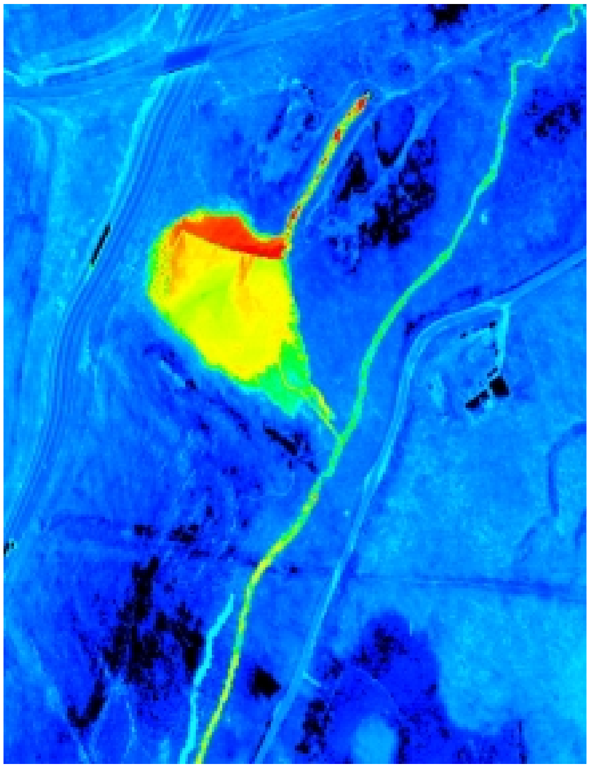
Figure 1. **Thermal image of an abandoned mine site, which discharges to Wilson Run (a tributary of Sewickley Creek). The red and yellow colors indicate warmer temperatures. An artesian discharge from an old shaft enters the pond containing a baffle, and subsequently, enters Wilson Run.**

Thermal IR images pinpointed areas of artesian discharge in the shallow river channel by showing thermal plumes or signatures. In addition, other locations where the warmer groundwater meets the cooler surface (on land and in streams and in wetlands) were identified. In the Sewickley Creek watershed many well-known mine drainage discharges were clearly identified by their thermal signatures. In addition, apparent septic tanks and sewage discharges were also identified. Ground-truthing/characterization of the numerous unknown targets is required and currently underway in cooperation with various government agencies and grass-roots organizations.

The primary issue being addressed with remote sensing technologies is the manageability of watersheds, which can be on the order of tens, hundreds, and even, thousands of square miles in size. The ability to locate, characterize and remediate water pollution sources on a watershed-basis or over large tracts of ground is overwhelming to both government agencies and watershed organizations. A "holistic" approach to watershed management, at present, is either rare or nonexistent. The size of watersheds typically prevents a holistic watershed approach from being pursued in a timely, efficient, and scientific manner. Rather, the norm is to select very manageable (e.g., small) subareas for analysis geared more toward investigating known, visible discharges and their impacts. This latter approach can detract from understanding the overall watershed condition and from identifying watershed restoration opportunities, including, in particular, non-point discharges. The holistic approach created by remote sensing generates new perspectives in terms of characterization and remediation. At present, there is a very short list of remedial options available to address the high volumes of water associated with underground mine discharges. Ground efforts need to expand the currently accepted characterization approaches and to focus on innovative water pollution prevention and treatment approaches.